

Beam dynamics study for AWA new beamline with three bending magnet set

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Motivation: To study beam dynamics of AWA new beamline with three quadrupoles and bending magnets from old driving beamline at the aid of PARMELA.

I. Introduction

AWA beamline used in the study, as shown in Fig. 1, consists of L-band 1.5-cell RF gun, one Linac tank, three quadrupoles and three bending magnets [1]. The initial beam parameters applied in the study are listed below:

Beam charge = 100nC,

Pulse length of laser = 8 ps FWHM ($\sim 3.75^\circ$),

Uniform transverse beam distribution with radius equal to 1cm.

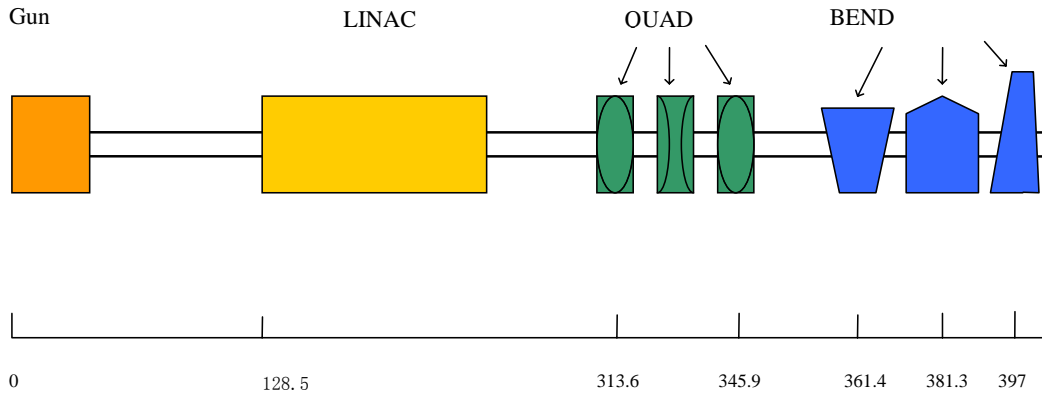


Fig. 1 Schematic of AWA beamline used in this study.

Three solenoids are used to compensate beam emittance growth in the gun region. They are bucking, focusing, and matching solenoid. The solenoid field map along the central axis is shown in Fig. 2.

Two cases are studied, one for high beam energy gain (19 MeV), and another for low beam energy gain (14 MeV). The detailed RF parameters setting and beam quality will be given in the following two sections.

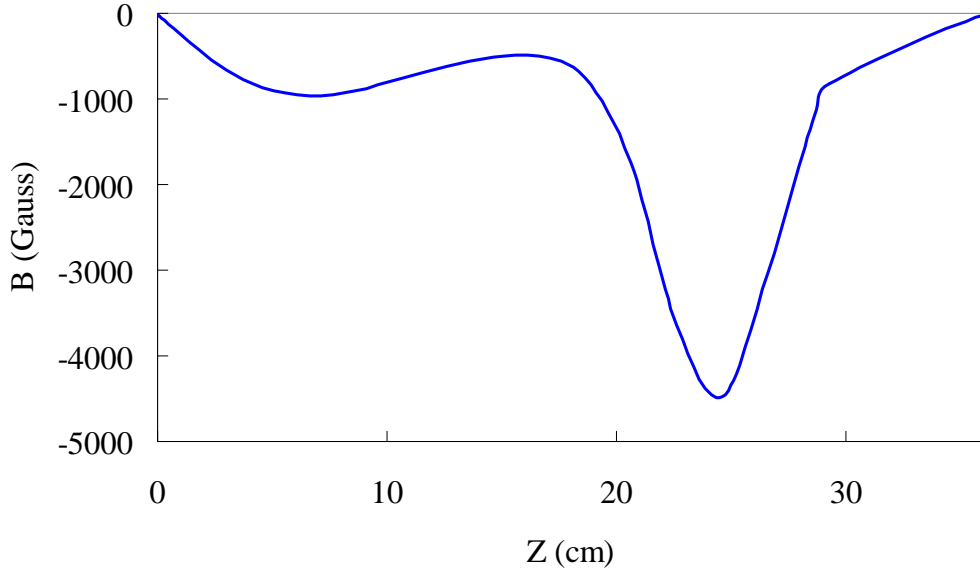


Fig. 2 Field map of bucking, focusing, and matching solenoid set along the central axis. $Z = 0$ shows the position of photocathode.

II. High-energy beam (19 MeV)

In this set of simulations, RF parameters for gun and Linac tank are adjusted, so that average beam energy gain equals to 19 MeV. The detailed settings of RF parameters are presented as below:

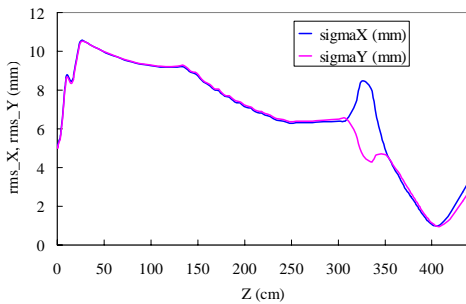
Maximum electric gradient on cathode = 80 MV/m,

RF launch phase of gun = 50° ,

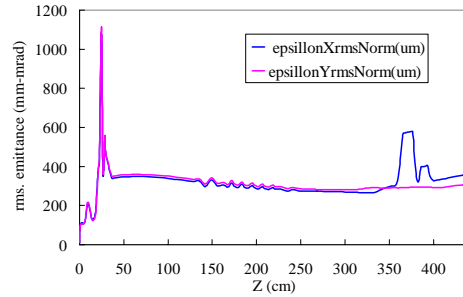
Average electric gradient of Linac = 10.67 MV/m,

RF launch phase of Linac = -134° .

Since the vertical half gap height $g/2$ at the bending magnets region equal to 0.95 cm, the three quadrupole must carefully be adjusted to get as more particles as possible to pass through the gap. PARMELA simulation showed that all the particles emitted from photocathode can pass through the bending magnet region with narrow vertical gap, that is, no beam loss exists in the whole beamline. Fig. 3 and Fig. 4 presented the simulation results.



(a)



(b)

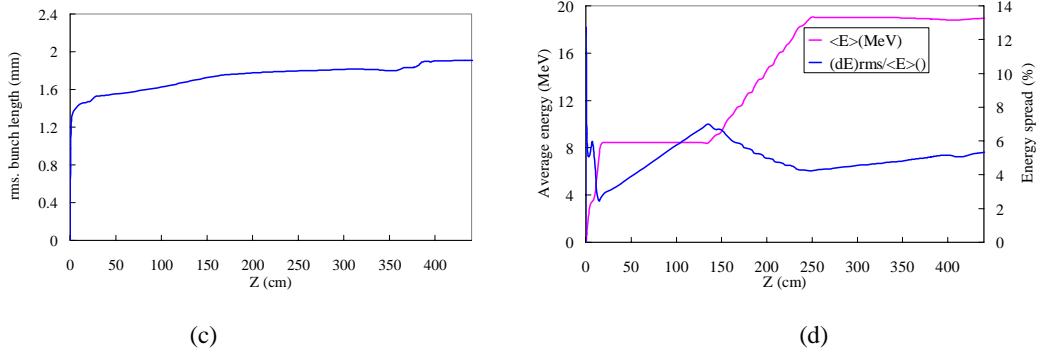


Fig.3. The evolution of beam qualities along the z axis; (a) rms. beam envelop, (b) rms. normalized transverse beam emittance, (c) rms. bunch length, (d) average beam energy and energy spread.

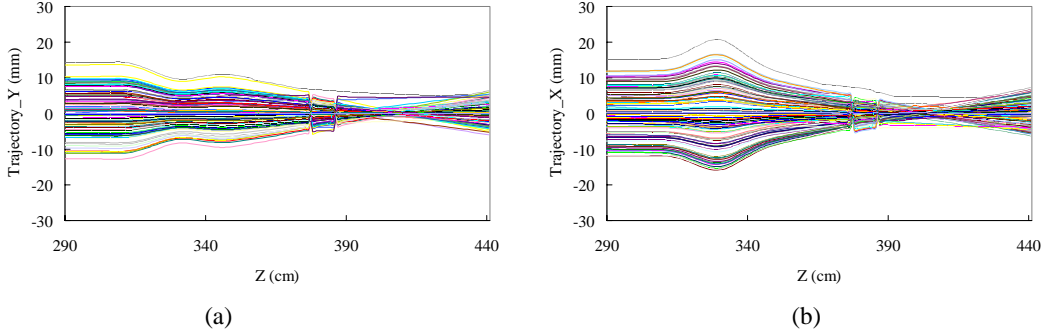
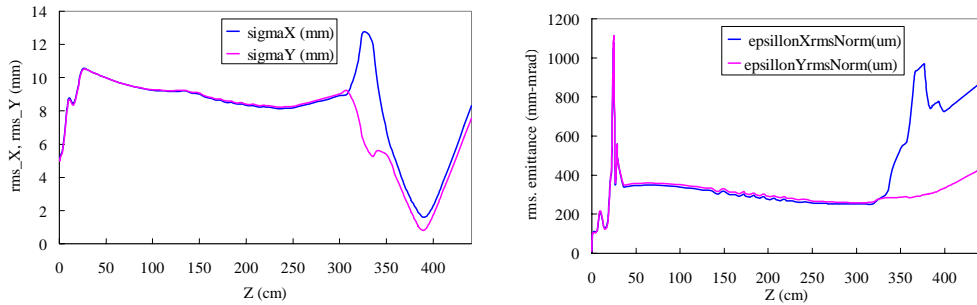


Fig. 4 Evolution of beam trajectories in horizontal (x) and vertical (y) directions.

III. Low-energy beam (14 MeV)

In this set of simulations, RF parameters for gun and Linac tank are adjusted, so that average beam energy gain equals to 14 MeV. The detailed settings of RF parameters are presented as below:
Maximum electric gradient on cathode = 80 MV/m,
RF launch phase of gun = 50° ,
Average electric gradient of Linac = 5.67 MV/m,
RF launch phase of Linac = -134° .

PARMELA simulation showed that there was less than 2% particles loss in the whole beamline, and all the beam loss happened at bending magnet set region with narrow vertical gap. Simulation results are presented in Fig. 5 and Fig. 6.



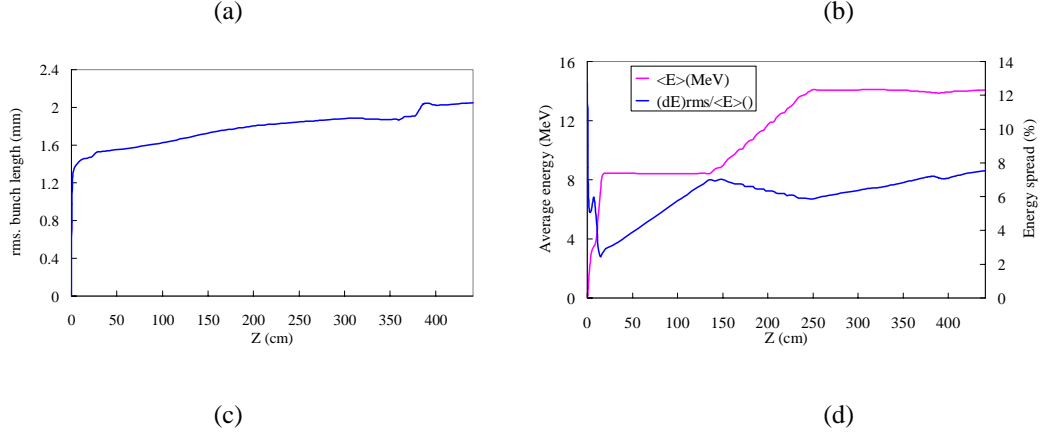


Fig. 5. The evolution of beam qualities along the z axis; (a) rms. beam envelop, (b) rms. normalized transverse beam emittance, (c) rms. bunch length, (d) average beam energy and energy spread.

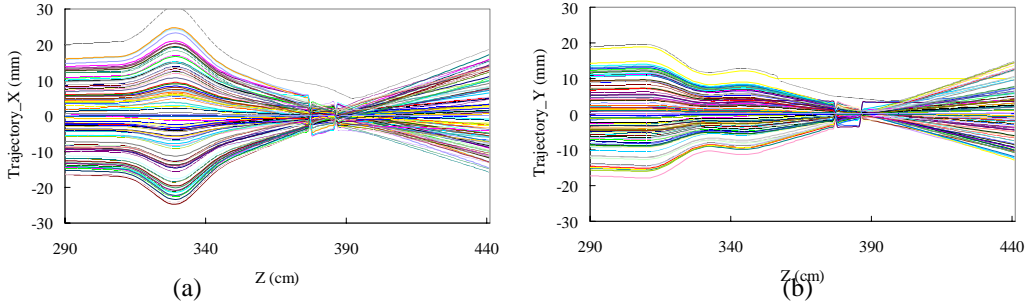


Fig. 6 Evolution of beam trajectories in horizontal (x) and vertical (y) directions.

IV. Conclusion

In this note, the study of beam dynamics by combining new beamline with three quads and bending magnets from old driving beamline was presented. Two beam energy levels were used in these simulations, one is 19MeV, and another is 14MeV. Simulations showed that almost no beam loss for high energy case and less than 2% beam loss for low energy case.

Reference

- [1] John power's thesis.